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Description

Method for monitoring a rotation rate sensor

5 The invention relates to a method for monitoring a rotation rate sensor with a vibrational gyroscope which has a first input and a first output which form part of a primary control loop which excites the vibrational gyroscope by supplying an excitation signal to the 10 first input at its natural frequency, where the vibrational gyroscope also has a second input and a second output which form part of a secondary control loop, where an output signal can be taken from the second output, said output signal being amplified and 15 subjected to analog/digital conversion and then demodulated into an inphase component and a quadrature component, where the components are filtered and are then modulated again and compiled to form a driver signal which is supplied to the second input, and where 20 a rotation rate signal is derived from the inphase component.

By way of example, EP 0 461 761 B1 has disclosed rotation rate sensors in which a vibrational gyroscope 25 is excited in two axes of radial orientation with respect to a main axis, to which end a primary control loop and a secondary control loop with appropriate transducers are provided on the vibrational gyroscope. If such rotation rate sensors are used in vehicles to 30 stabilize the vehicle motion, then risks may arise as a result of failure or incorrect operation. To avoid this, it is necessary to monitor the operation of the rotation rate sensor.

35 Such monitoring is advantageously performed in the inventive method by virtue of  
- the inphase component and the quadrature component having a test signal added to them whose frequency

brings about sidebands which are situated in the driver signal outside of the second control loop's passband.

- the respective test signal which is present in the inphase component and in the quadrature component after passing through the control loop being monitored, and
- an error message being output if the amplitude is below a prescribed threshold value.

10 The inventive method allows monitoring of the operation of the entire control loop including the vibrational gyroscope during operation without influencing the operation of the rotation rate sensor in any way.

15 One advantageous development of the inventive method involves measurement signals being taken from the components prior to the addition of the test signal and being synchronously demodulated.

20 In another development, it is possible to detect as many alterations as possible in the secondary control loop by virtue of the measurement signals from both components respectively being monitored for their amplitude, for the ratio of the amplitudes and/or for their phase. In this case, provision is preferably made for measurement signals to be derived before and after the components are filtered.

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30 Since the sidebands resulting from the modulation and hence also the modulation signal and the measurement signals have extremely small amplitudes, the noise may be suppressed by providing for the synchronously demodulated measurement signals to be integrated over a prescribed time and for the value of the integral to be compared with the prescribed threshold value.

35 Alternatively, the method may also be in a form such that the synchronously demodulated measurement signals are integrated and that the time before the integrated

measurements signals reach a prescribed threshold value is measured.

5 In the case of the known vibrational gyroscopes, it has been found to be beneficial if the modulation signal has a frequency of 200 Hz.

10 The invention permits numerous embodiments. One of these is shown schematically in the drawing with reference to a plurality of figures and is described below. In the drawing:

Figure 1 shows a block diagram of a rotation rate sensor, and

15 Figure 2 shows a more detailed illustration of a secondary control loop in the rotation rate sensor.

20 Although the exemplary embodiment and parts thereof are shown as block diagrams, this does not mean that the inventive arrangement is limited to being implemented using individual circuits corresponding to the blocks. Rather, the inventive arrangement can be implemented 25 particularly advantageously using large-scale integrated circuits. In this case, microprocessors may be used which, with suitable programming, perform the processing steps shown in the block diagrams.

30 Figure 1 shows a block diagram of an arrangement with a vibrational gyroscope 1 having two inputs 2, 3 for a primary excitation signal PD and a secondary excitation signal SD. The excitation is produced by suitable transducers, for example electromagnetic transducers. 35 The vibrational gyroscope also has two outputs 4, 5 for a primary output signal PO and a secondary output signal SO. These signals forward the respective vibration to physically offset points on the gyroscope. Such gyroscopes are known from EP 0 307 321 A1, for

example, and are based on the effect of the Coriolis force.

The vibrational gyroscope 1 represents a high quality filter, with the section between the input 2 and the output 4 being part of a primary control loop 6 and the section between the input 3 and the output 5 being part of a secondary control loop 7. The primary control loop 6 is used to excite oscillations at the resonant frequency of the vibrational gyroscope, for example 14 kHz. In this case, the excitation is produced in an axis of the vibrational gyroscope with respect to when the direction of oscillation used for the secondary control loop is offset through 90°. In the secondary control loop 7, the signal SO is split into an inphase component and a quadrature component, one of which is supplied via a filter 8 to an output 9 from which a signal which is proportional to the rotation rate can be picked off.

In both control loops 6, 7, a fundamental part of the signal processing is performed digitally. The clock signals required for the signal processing are produced in a crystal-controlled digital frequency synthesizer 10 whose clock frequency is 14.5 MHz in the example shown. An explanation of the primary control loop is not given, since this is not necessary in order to understand the exemplary embodiment.

The secondary control loop 7 is shown as a block diagram in Figure 2 and contains an amplifier 25, an antialiasing filter 26 and an analog/digital converter 27. Using multipliers 28, 29 to which the amplified and digitized signal SO and carrier  $T_{i1}$  and  $T_{q1}$  are supplied, splitting is performed to produce an inphase component and a quadrature component.

The two components then respectively pass through a  $(\sin x/x)$  filter 30, 31 and a low-pass filter 32, 33. A

conditioning circuit 34 is used to derive from the filtered real part two signals R1 and R2 which represent the rotation rate which is to be measured with the rotation rate sensor. The signals R1 and R2 differ in that the signal R2 does not adopt the entire amplitude range of between 0V and +5V for example, which is possible with the circuitry used. To output an error message, the signal R2 is changed to zero, which the connected system identifies as an error message.

10 The low pass filters 32, 33 have a respective adder 35, 36 connected downstream of them. Next, multipliers 37, 38 are used to remodulate the two components Si and Sq with carriers Ti2 and Tq2. An addition at 39 produces a 15 14-kHz oscillation again, which is converted in an output deliver 40 into a current which is suitable for exciting the vibrational gyroscope 1.

20 To carry out the inventive method, a modulation signal 200 Hz is produced in a generator 41. Two multipliers 42, 43 multiply this signal by constants k1 and k2, which are variable and are loaded from a memory upon turning on, as a result of which the amplitudes of the test signal for the two components can be set 25 independently of one another. Subsequent adders 44, 45 add variable bias voltages k3 and k4. The test signal's components derived in this manner are added to the inphase component and to the quadrature component in the adders 35 and 36. The subsequent multipliers 37, 38 and the adder 39 then modulate the carrier signal with 30 the recompiled demodulated output signal and additionally with the modulation signal.

35 The components obtained from the output 5 of the vibrational gyroscope after amplification, antialias filtering 26, analog/digital conversion and demodulation at 28, 39 are respectively tapped off upstream of the filters 32, 33 and downstream of the filters 32, 33 and are supplied as measurement signals

to a multiplexer 46 whose output is connected to a multiplier 47 which serves as a synchronous demodulator. The latter's output signal is integrated at 48 over a relatively large number of periods and is supplied to a threshold value circuit 49. The presence of the test signals is established by virtue of the respective integral exceeding a prescribed threshold value within a prescribed time. If this is not the case, an alarm signal is output at 50. A phase error in at least one of the test signals is likewise established by virtue of the synchronous demodulation.